FM1 and FM2 Edition3 Spectral Darkening Correction & Validation

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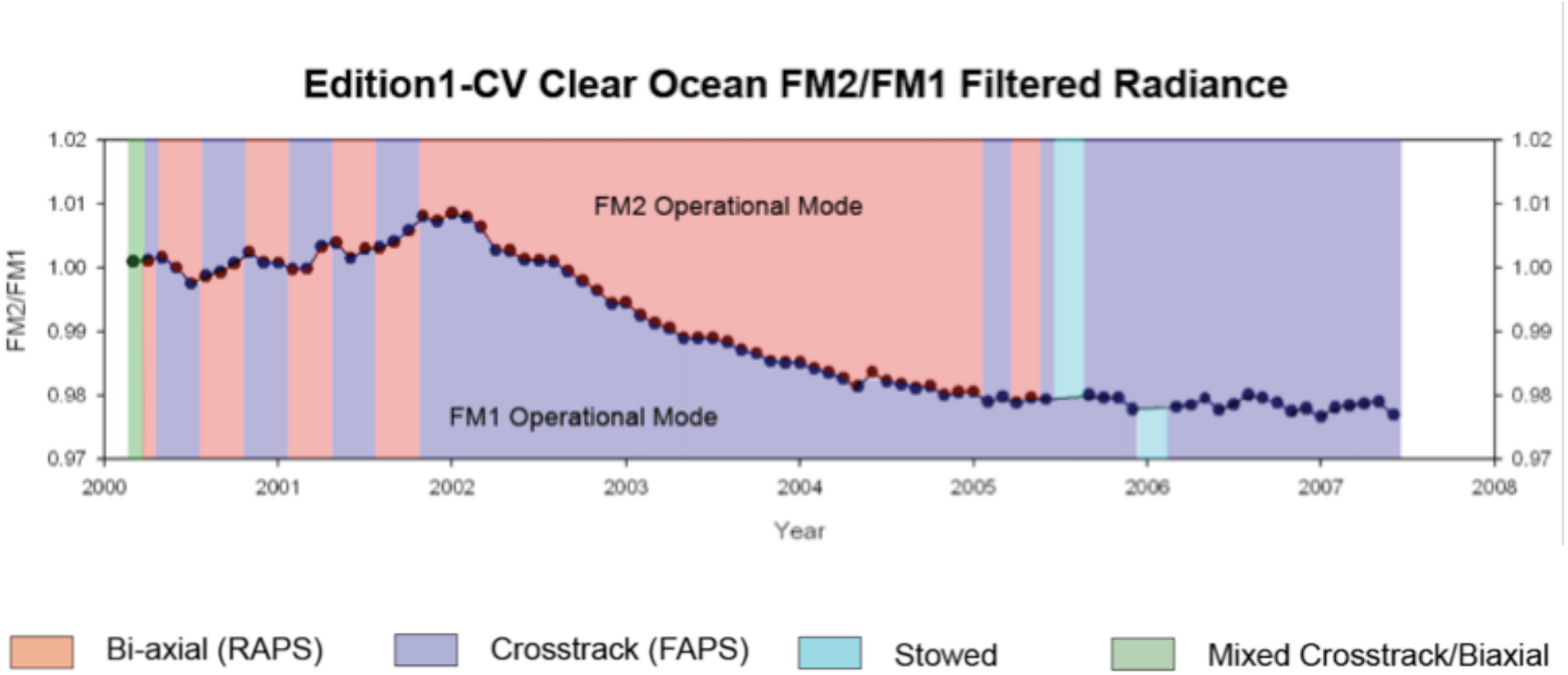
Edition3 Studies

- Spectral response degradation in SW channel
  - determine time-dependent "optimal" SRFs from Direct Compare approach
  - incorporate temporally varying SRFs in the SW measurements (implemented in spectral unfiltering algorithm)
- Divergence between daytime and nighttime OLR records with time



❖*Instrument operating in RAPS mode drops in SW response relative to instrument operating in cross-track mode.*

Strategy for Characterizing Spectral Degradation (Direct Nadir Radiance Comparison)

- Assume any temporal variation in FM2/FM1 SW unfiltered radiance ratio is caused by changes in spectral response function (SRF) only.

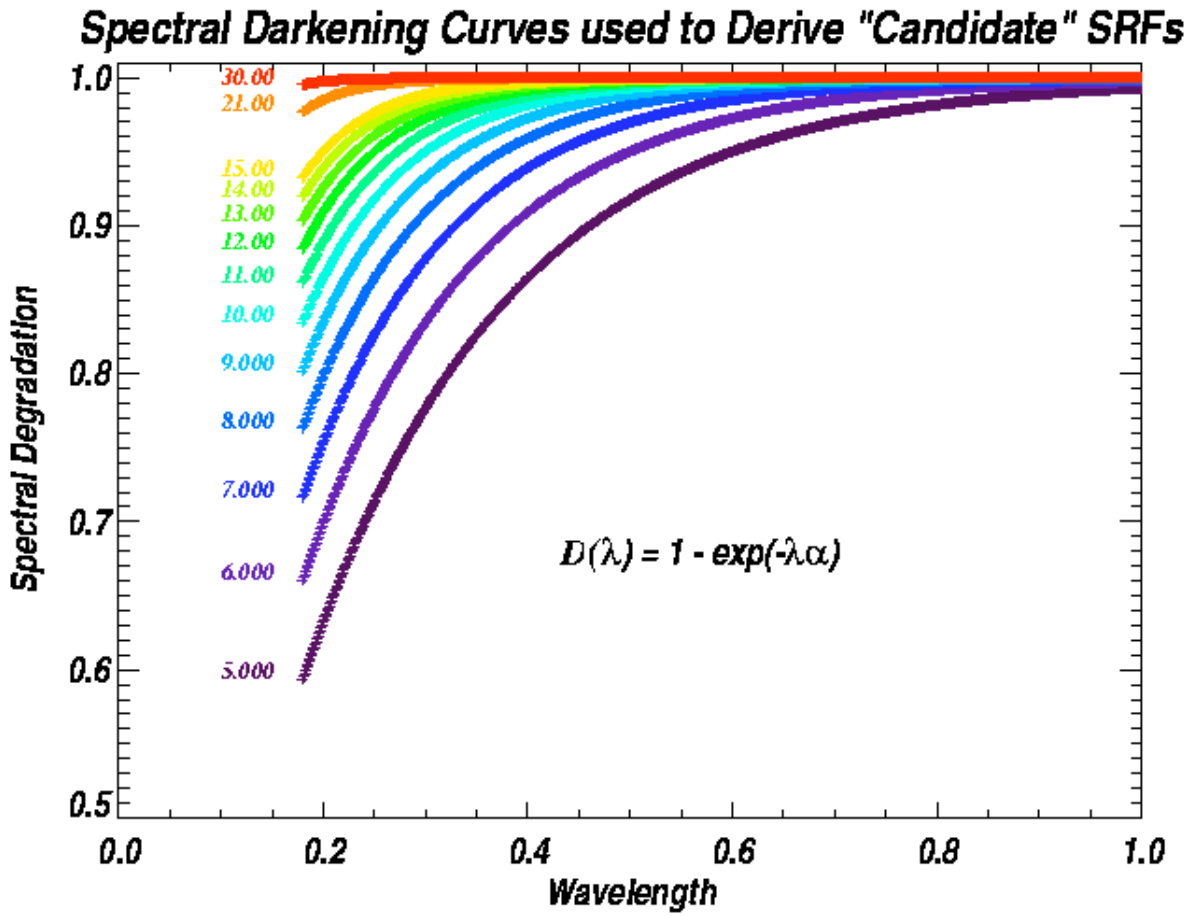
- Assume SRF changes occur only when instrument is in RAP mode.

- Compare spatially/temporally matched nadir FM1 and FM2 footprint radiance pairs (Clear ocean shows largest sensitivity to RAPS spectral darkening).

- Apply gains to Xtrack and RAP instruments.

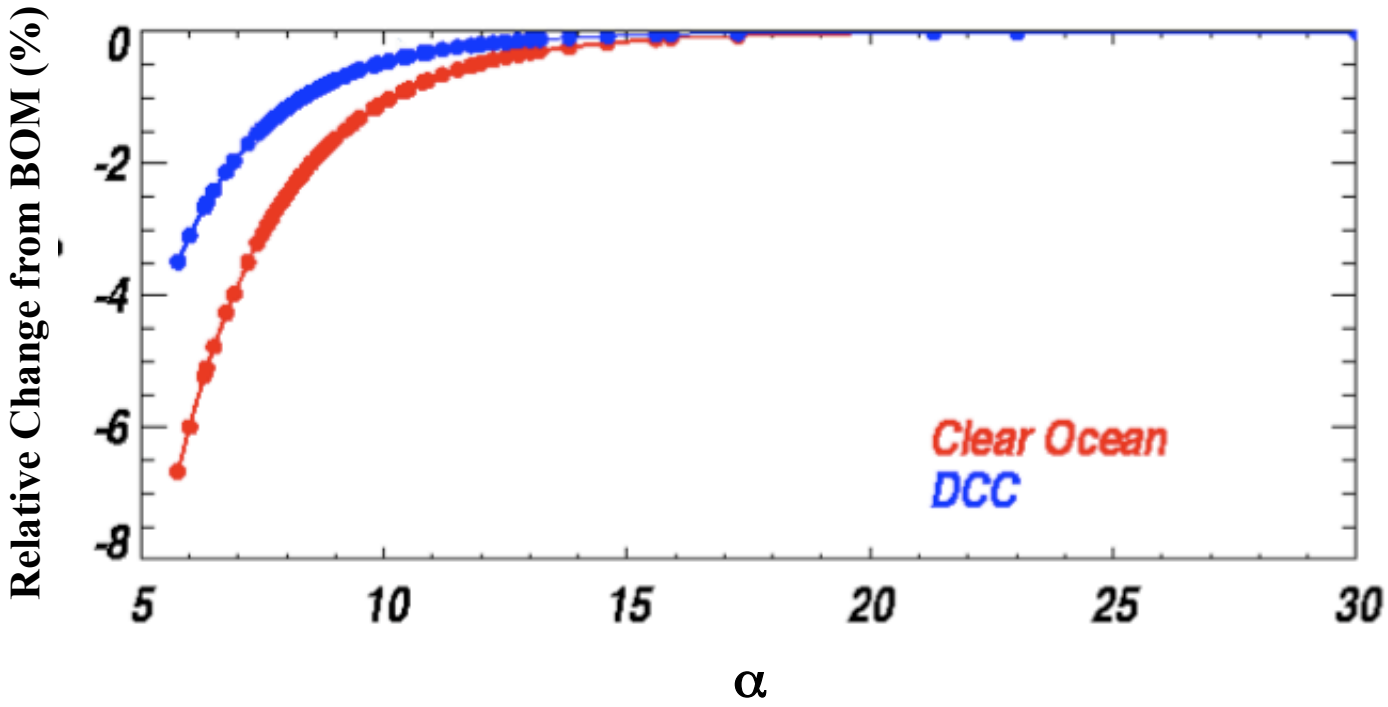
- For instrument in Xtrack mode, unfilter with previous month's SRF.

- From a set of candidate SRFs with varying degrees of spectral darkening, retrieve RAP SRF that ensures constant SW unfiltered FM2/FM1 radiance ratio throughout the mission.

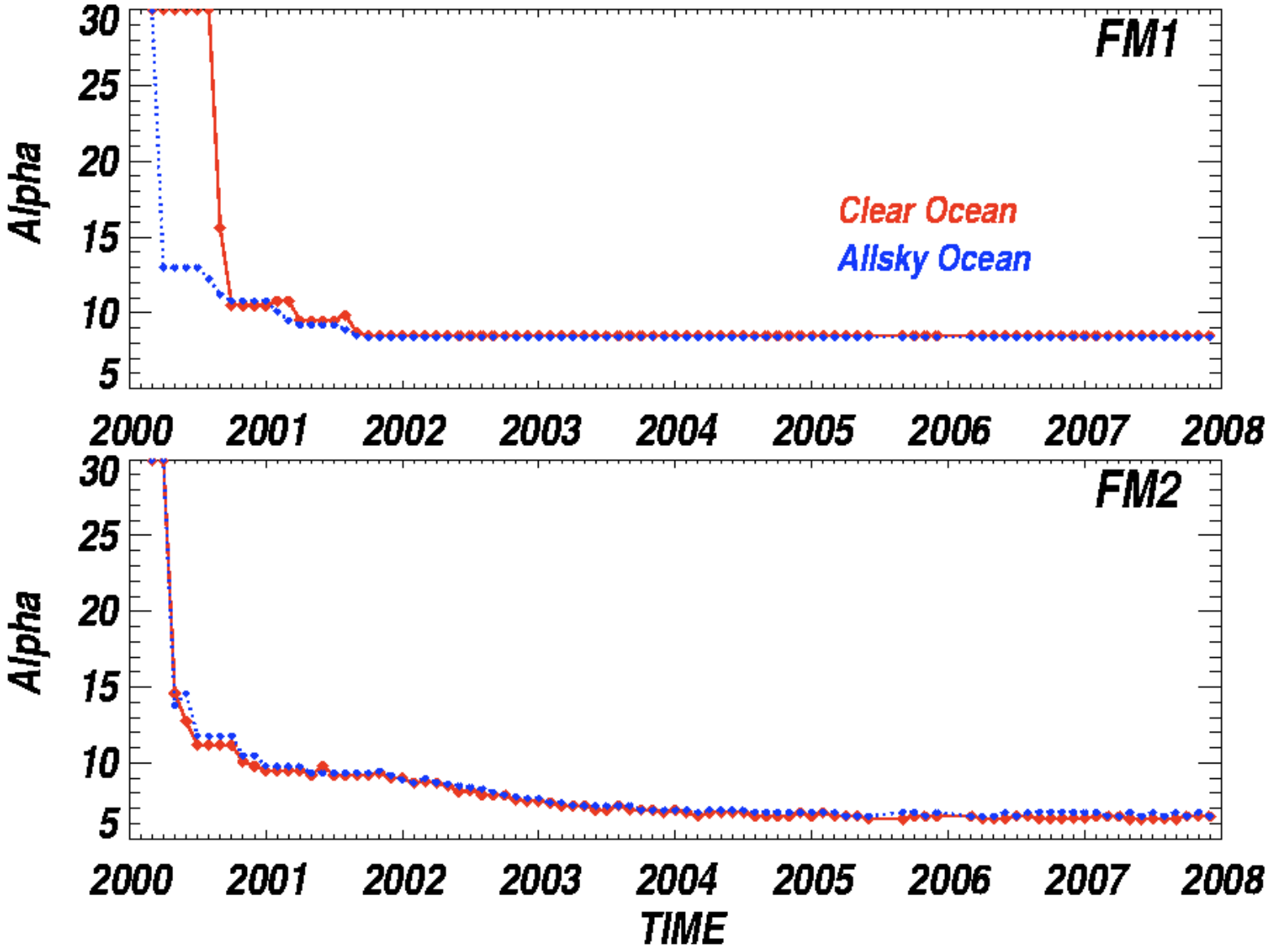


- ***Spectral degradation function similar to that observed in other missions (e.g. GOME, LDEF)***
- ***Spectral darkening increases with shorter wavelengths.***
- ***Plot shown is only a subset of the 53 "candidate" SRFs.***

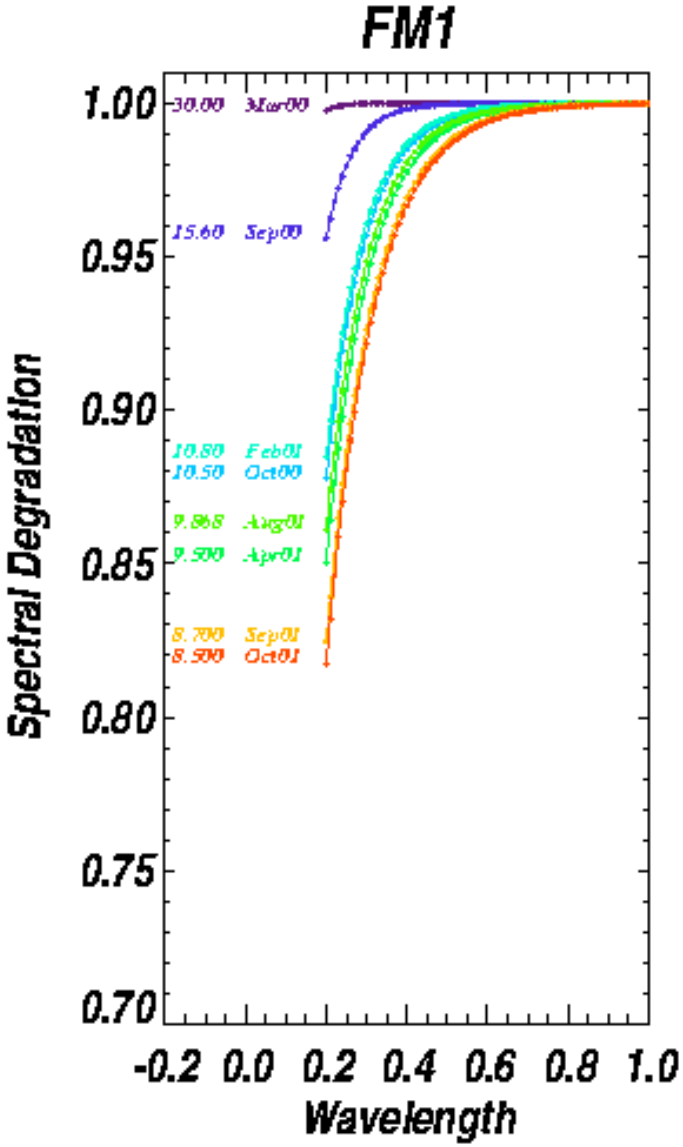
Approximate Relationship between Spectral Darkening Parameter and SW Radiance Changes since BOM

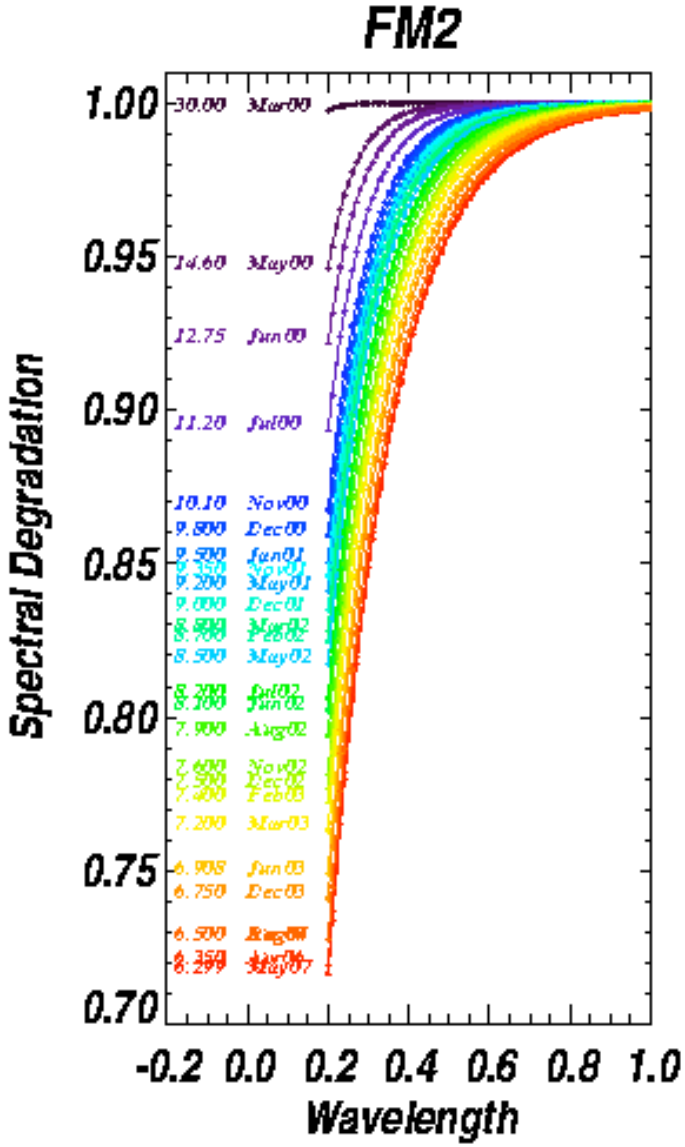


SW Degradation Parameter, α, Derived from Clear and All-sky Ocean Direct Compare Method

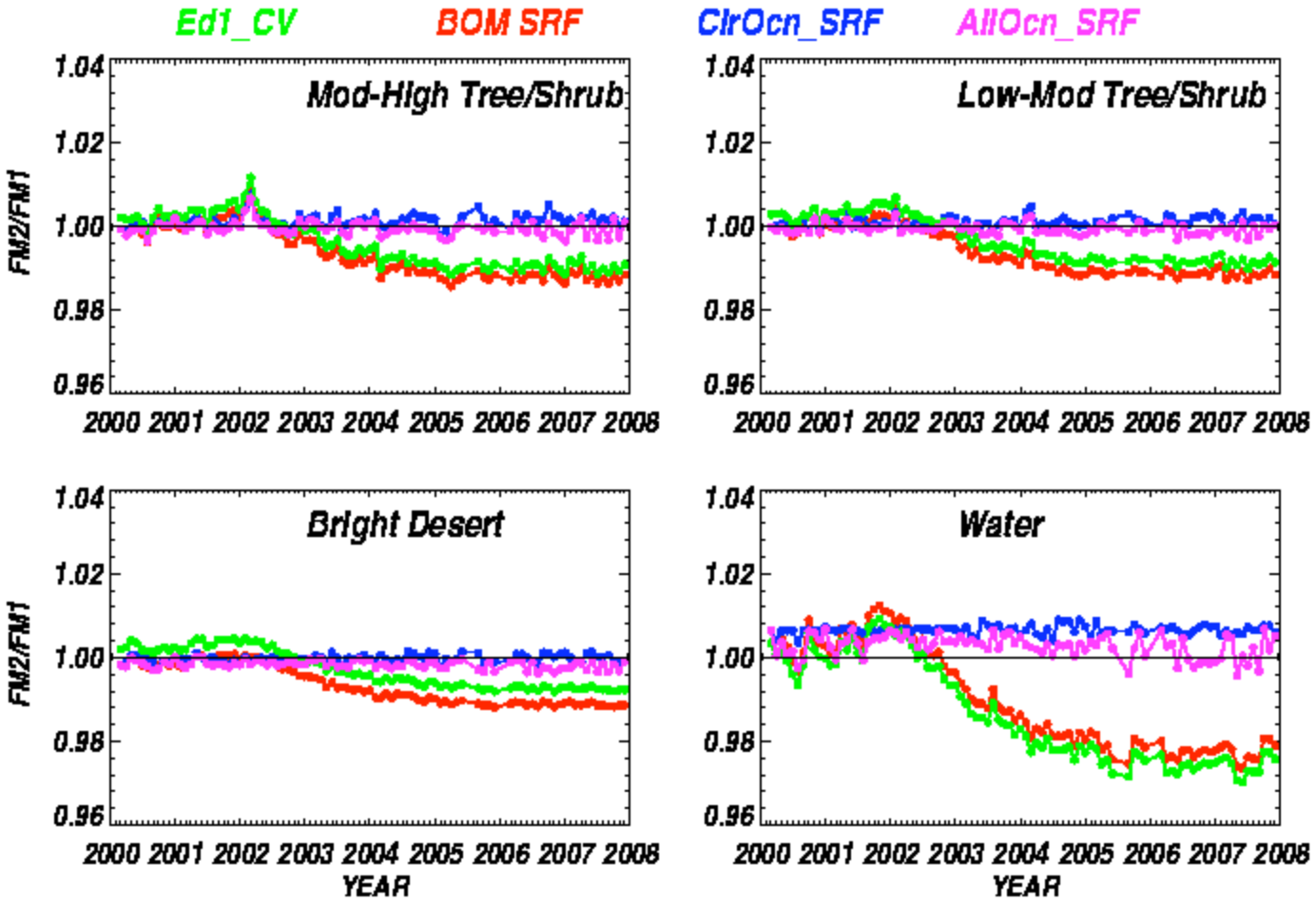


Alpha Retrieval Results



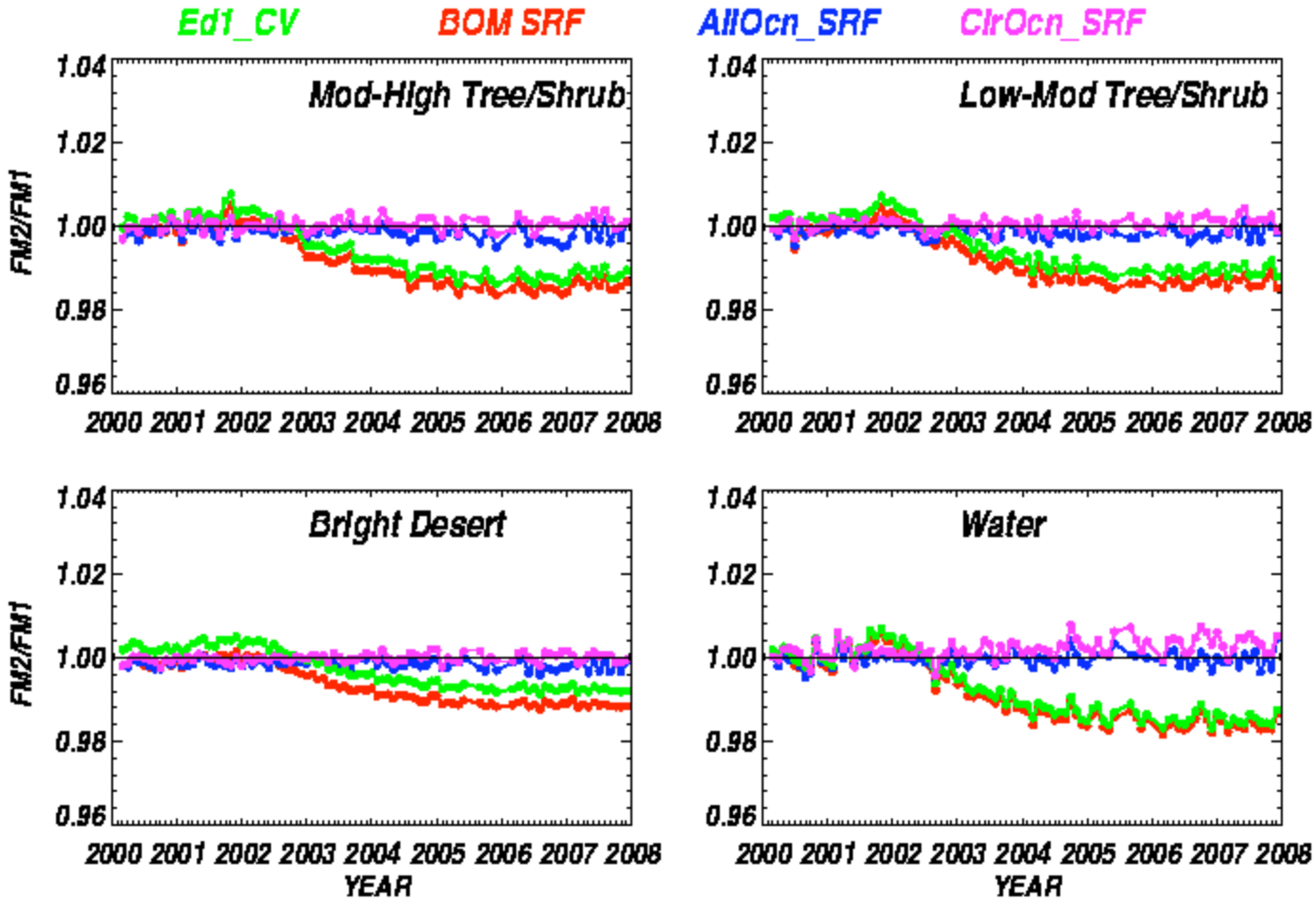


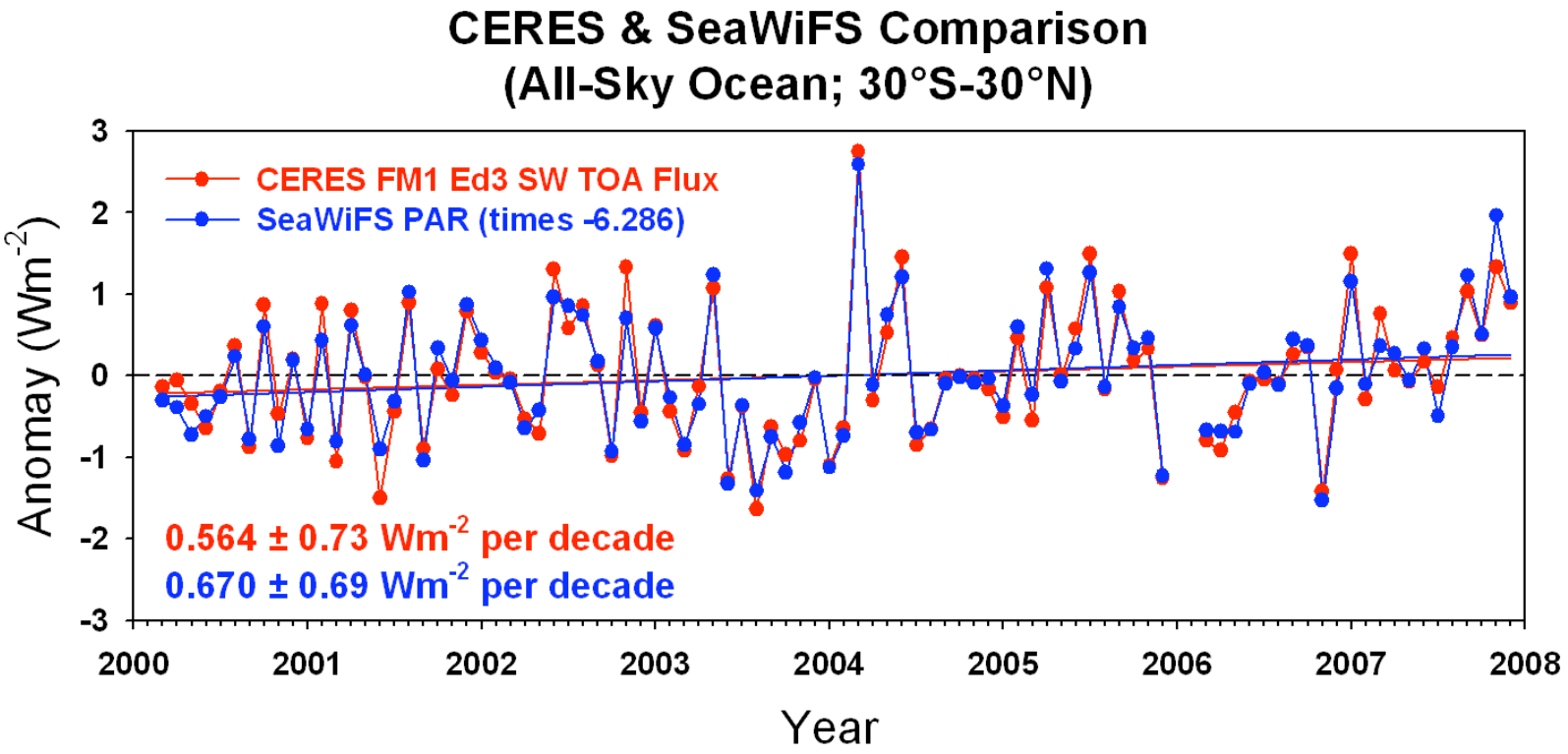
FM2/FM1 SW Unfiltered Radiance Ratio for Clear Sky Scenes



- ***Ed1_CV* and *BOM(new)* SRF – no attempt to correct for spectral darkening**
- ***Simple model works for all scene types.***

FM2/FM1 SW Unfiltered Radiance Ratio for <u>All Sky Scenes</u>





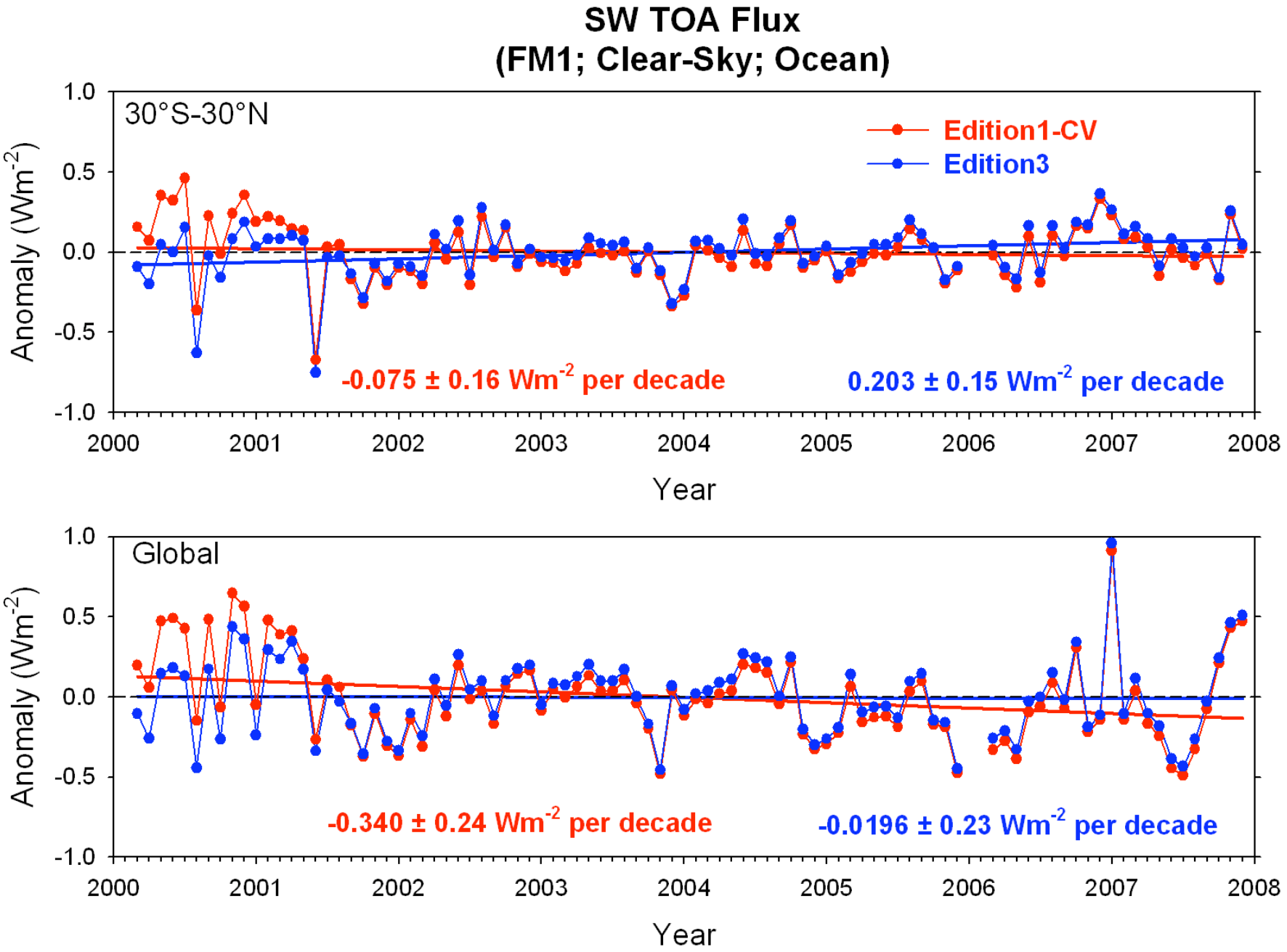
CERES Anom Minus SeaWiFS Anom: -0.106 ± 0.2 Wm^{-2} per decade

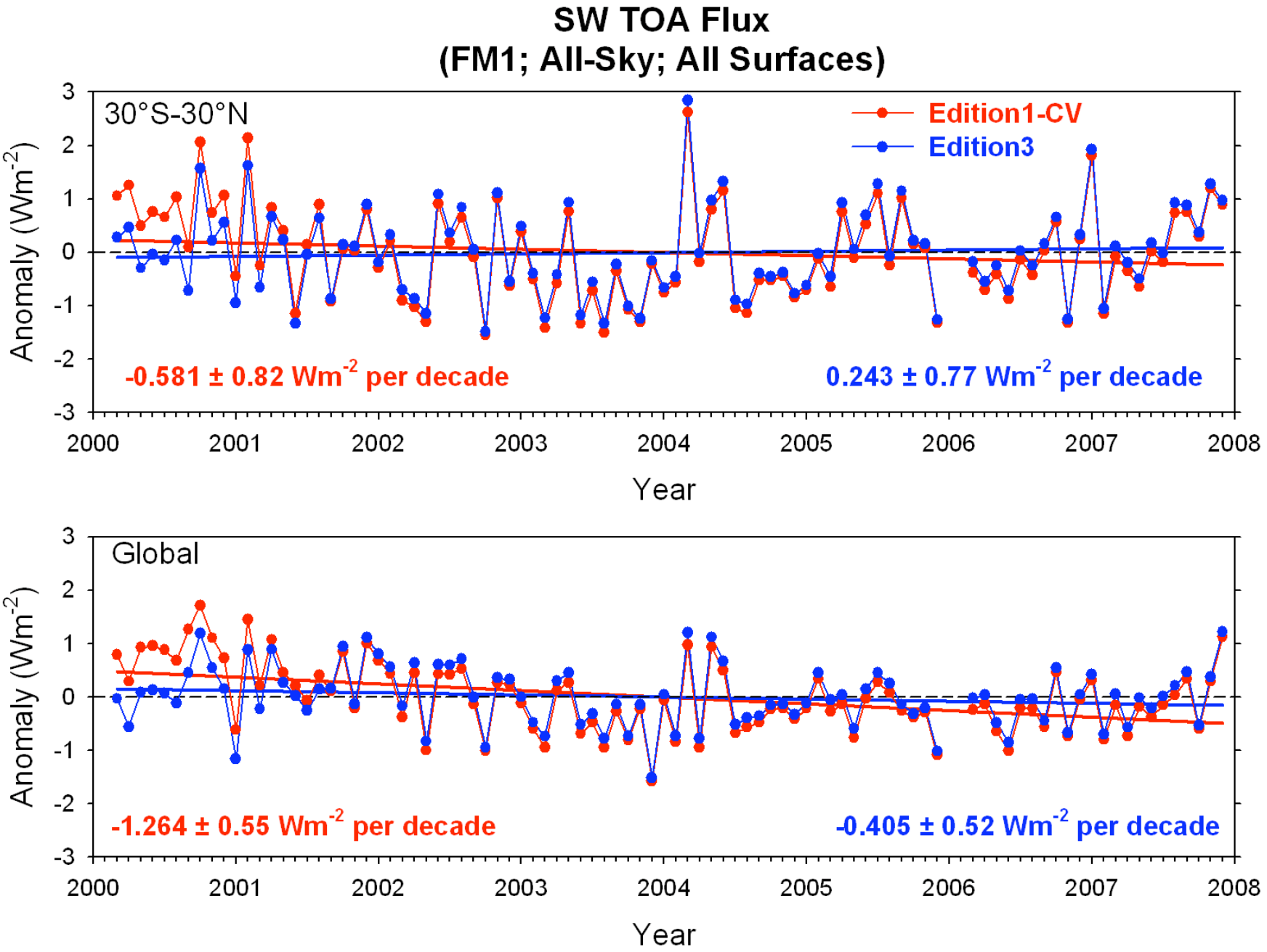
CERES Variability (1σ) = 0.79 Wm^{-2}

SeaWiFS Variability (1σ) = 0.76 Wm^{-2}

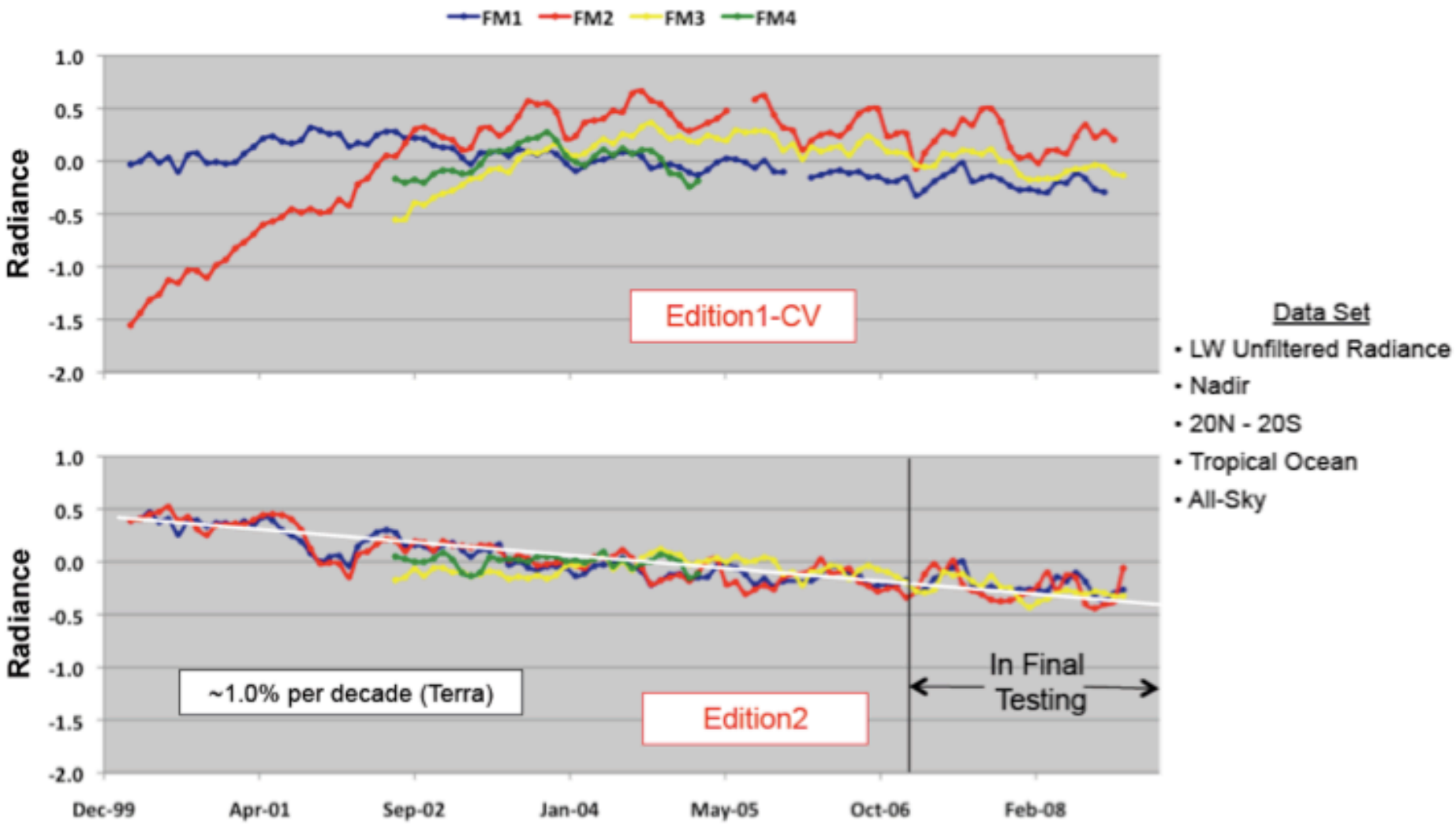
σ(CERES - SeaWiFS) = 0.21 Wm^{-2}

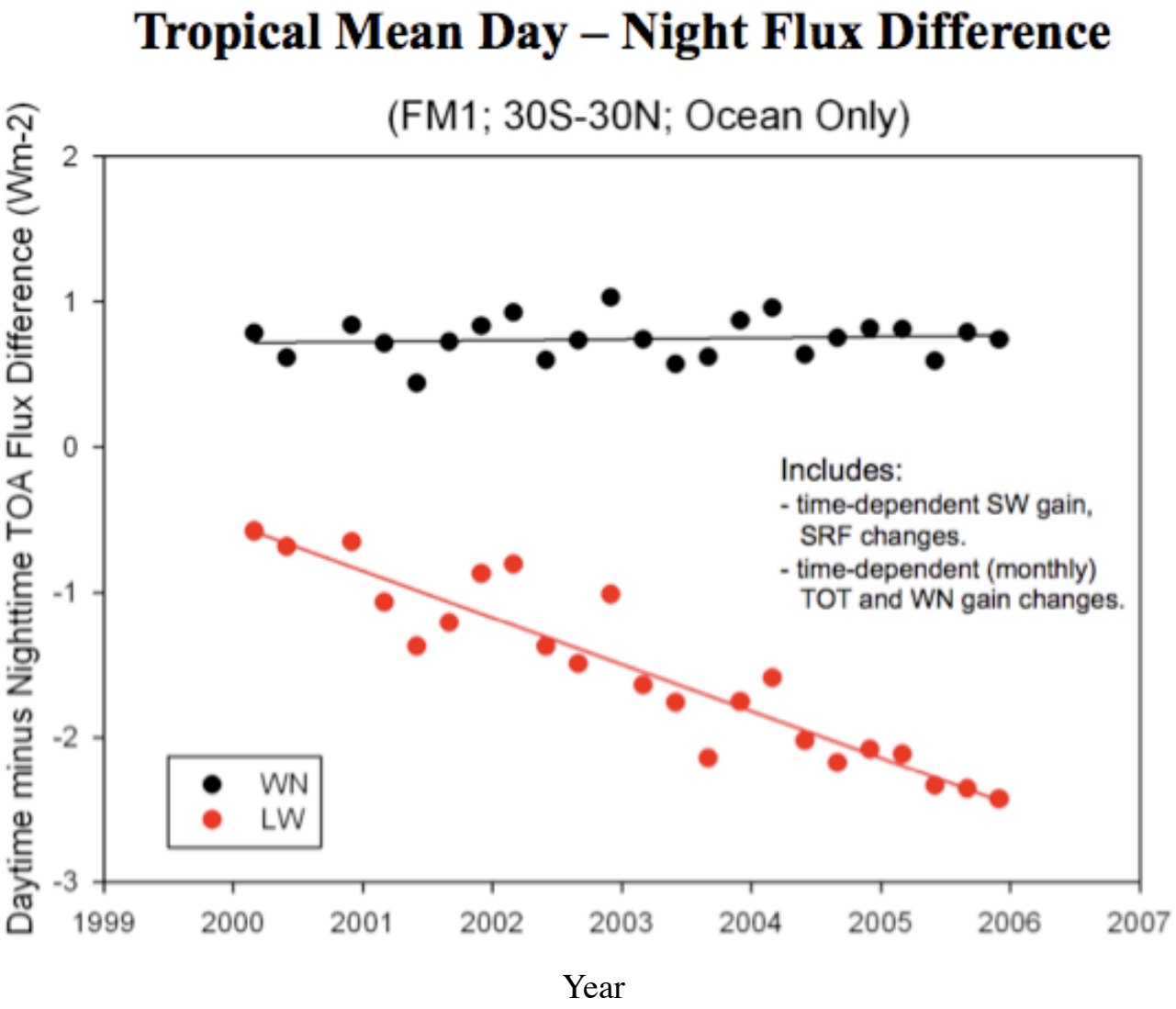
❖ ***Shows consistent calibration stability at < 0.3 Wm^2 per decade (95% conf)***


SW TOA Flux
(FM1; Clear-Sky; Ocean)
30°S-30°N
Edition1-CV
Edition3
-0.075 ± 0.16 Wm-2 per decade
0.203 ± 0.15 Wm-2 per decade
Anomaly (Wm-2)
Year
Global
-0.340 ± 0.24 Wm-2 per decade
-0.0196 ± 0.23 Wm-2 per decade
Anomaly (Wm-2)
Year

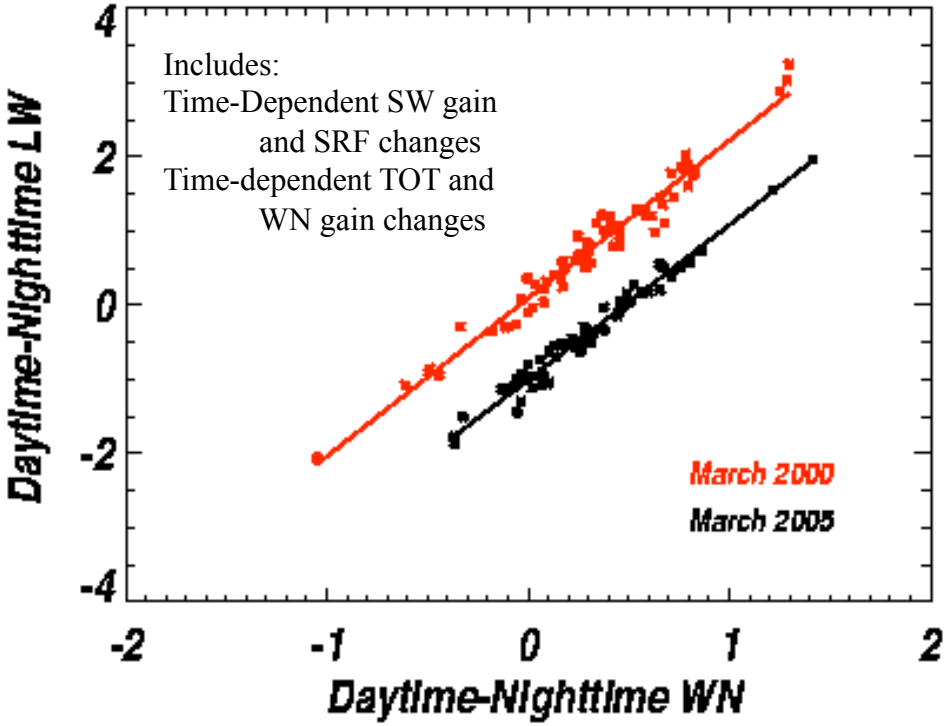

SW TOA Flux
(FM1; All-Sky; All Surfaces)
30°S-30°N
Edition1-CV
Edition3
-0.581 ± 0.82 Wm-2 per decade
0.243 ± 0.77 Wm-2 per decade
Anomaly (Wm-2)
Year
Global
-1.264 ± 0.55 Wm-2 per decade
-0.405 ± 0.52 Wm-2 per decade
Anomaly (Wm-2)
Year

Tropical Mean : LW Day Night Difference Trends




Tropical Mean Day – Night Flux Difference
(FM1; 30S-30N; Ocean Only)
Daytime minus Nighttime TOA Flux Difference (Wm-2)
2
1
0
-1
-2
-3
1999
2000
2001
2002
2003
2004
2005
2006
2007
Includes:
- time-dependent SW gain, SRF changes.
- time-dependent (monthly) TOT and WN gain changes.
WN
LW
Year

FM1 Zonal Averages of Unfiltered Radiances for All-Sky Ocean (30S – 30N)



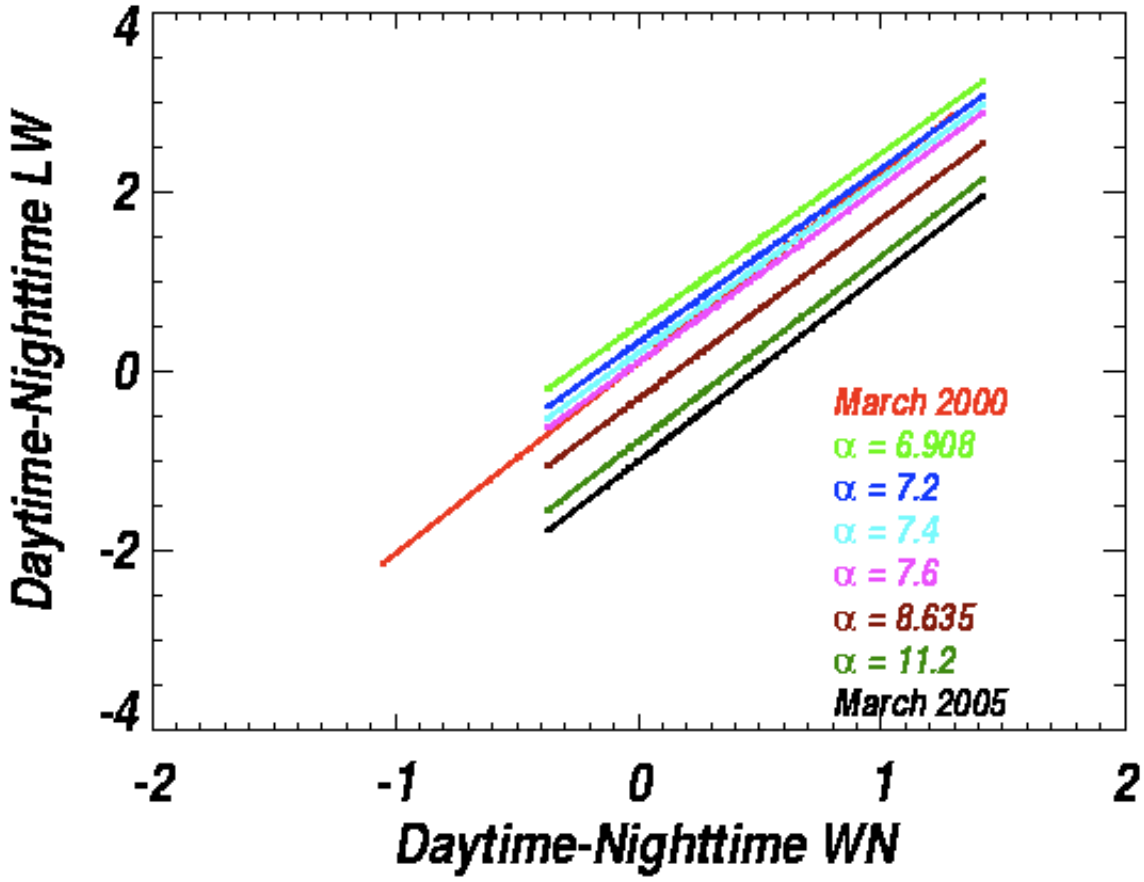
LW Day Night Difference Trends

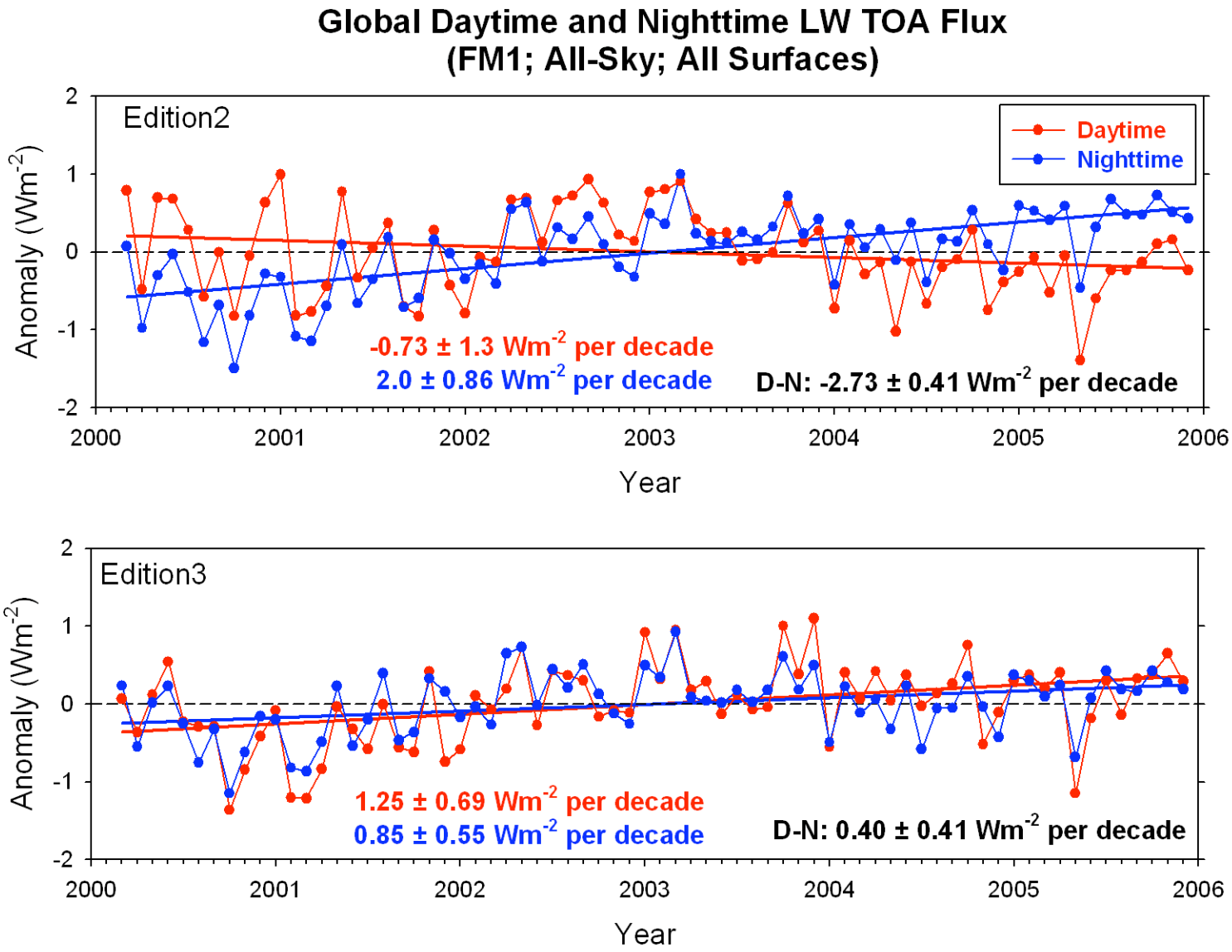
$$LW_{day} = Total - Shortwave$$
$$LW_{night} = Total$$

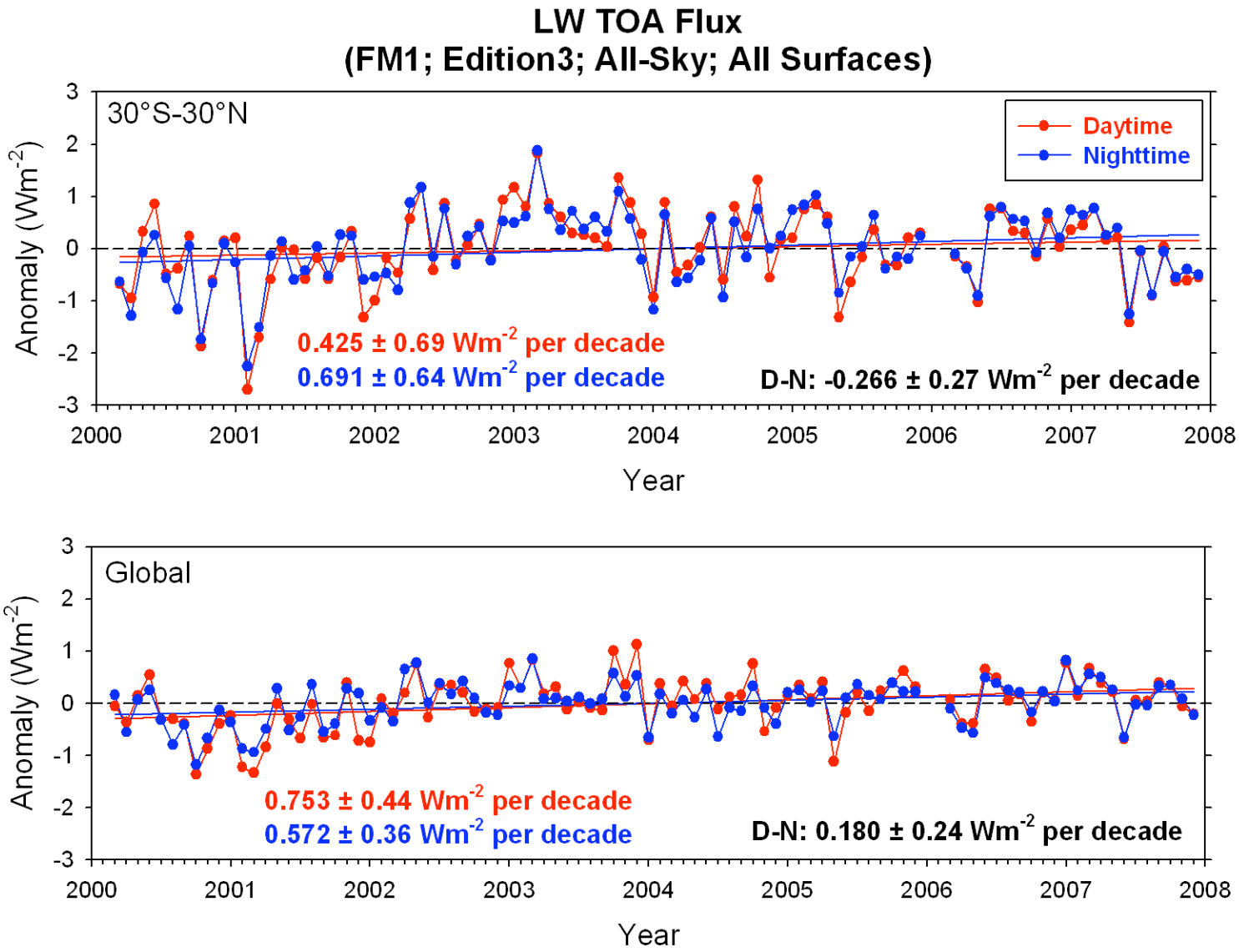
- Apply Total and WN gains.

- With SW spectral darkening compensated for by selected SW optimal SRFs, select Total SRF from a “candidate” set of SRFs that eliminates monthly offsets from Beginning of Mission (BOM).

Determining the Optimal Total SRF with ΔLW and ΔWN Unfiltered Radiances




Global Daytime and Nighttime LW TOA Flux
(FM1; All-Sky; All Surfaces)
Edition2
Daytime
Nighttime
Anomaly (Wm-2)
-0.73 ± 1.3 Wm-2 per decade
2.0 ± 0.86 Wm-2 per decade
D-N: -2.73 ± 0.41 Wm-2 per decade
Year
Edition3
1.25 ± 0.69 Wm-2 per decade
0.85 ± 0.55 Wm-2 per decade
D-N: 0.40 ± 0.41 Wm-2 per decade
Year


LW TOA Flux
(FM1; Edition3; All-Sky; All Surfaces)
30°S-30°N
Daytime
Nighttime
Anomaly (Wm-2)
0.425 ± 0.69 Wm-2 per decade
0.691 ± 0.64 Wm-2 per decade
D-N: -0.266 ± 0.27 Wm-2 per decade
Year
Global
0.753 ± 0.44 Wm-2 per decade
0.572 ± 0.36 Wm-2 per decade
D-N: 0.180 ± 0.24 Wm-2 per decade
Year

Summary

- Direct Compare method to select time-dependent ‘optimal’ SRFs was implemented to characterize spectral darkening. Application of monthly SRFs to all scene types removed SW degradation trend.

- There are no significant day night differences after Total channel optimal SRFs are applied.

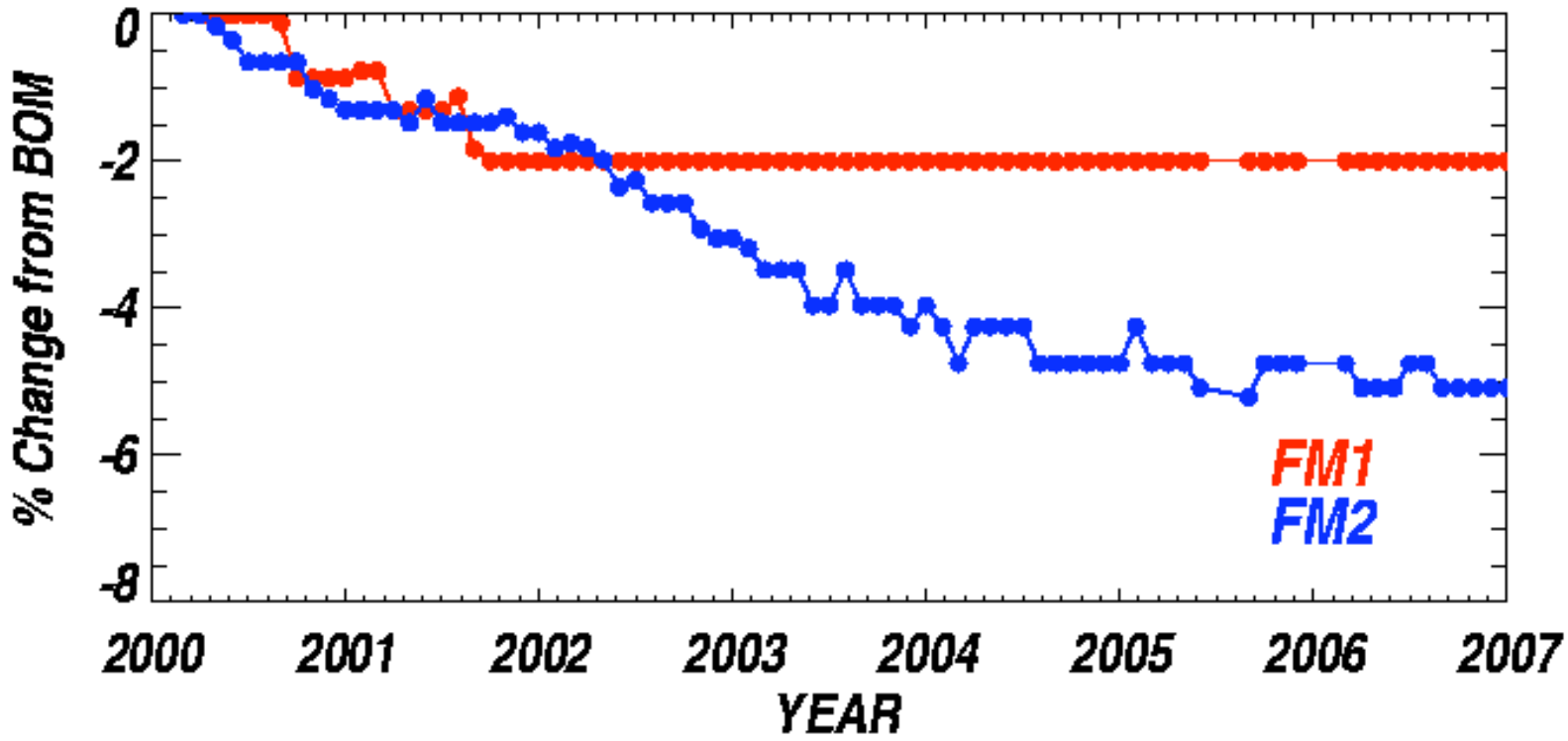
- Excellent agreement between CERES and SeaWiFS anomaly trends in the tropical region .

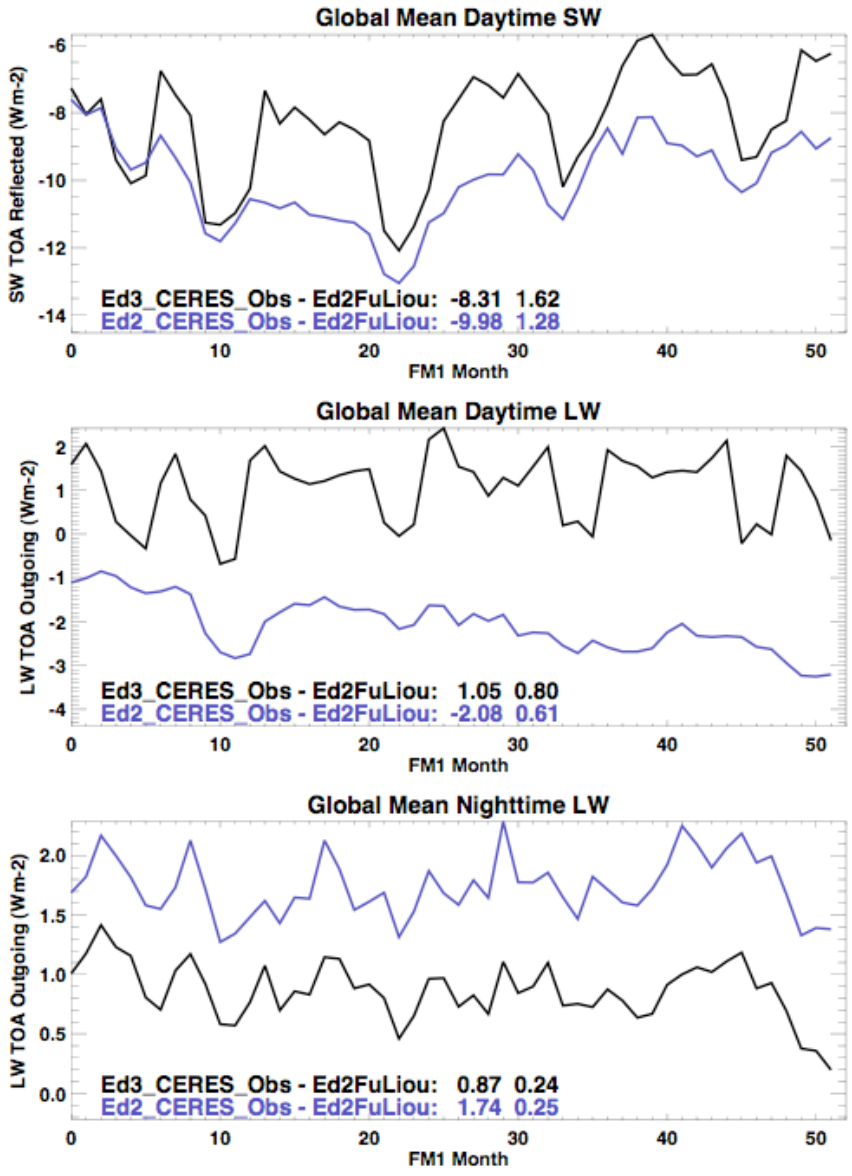
BACK-UP SLIDES

Edition2 Calibration Studies

Residual calibration errors in CERES Edition2 data products are dominated by spectral degradation of sensor optics in the reflected solar bands (SW and SW/TOT)

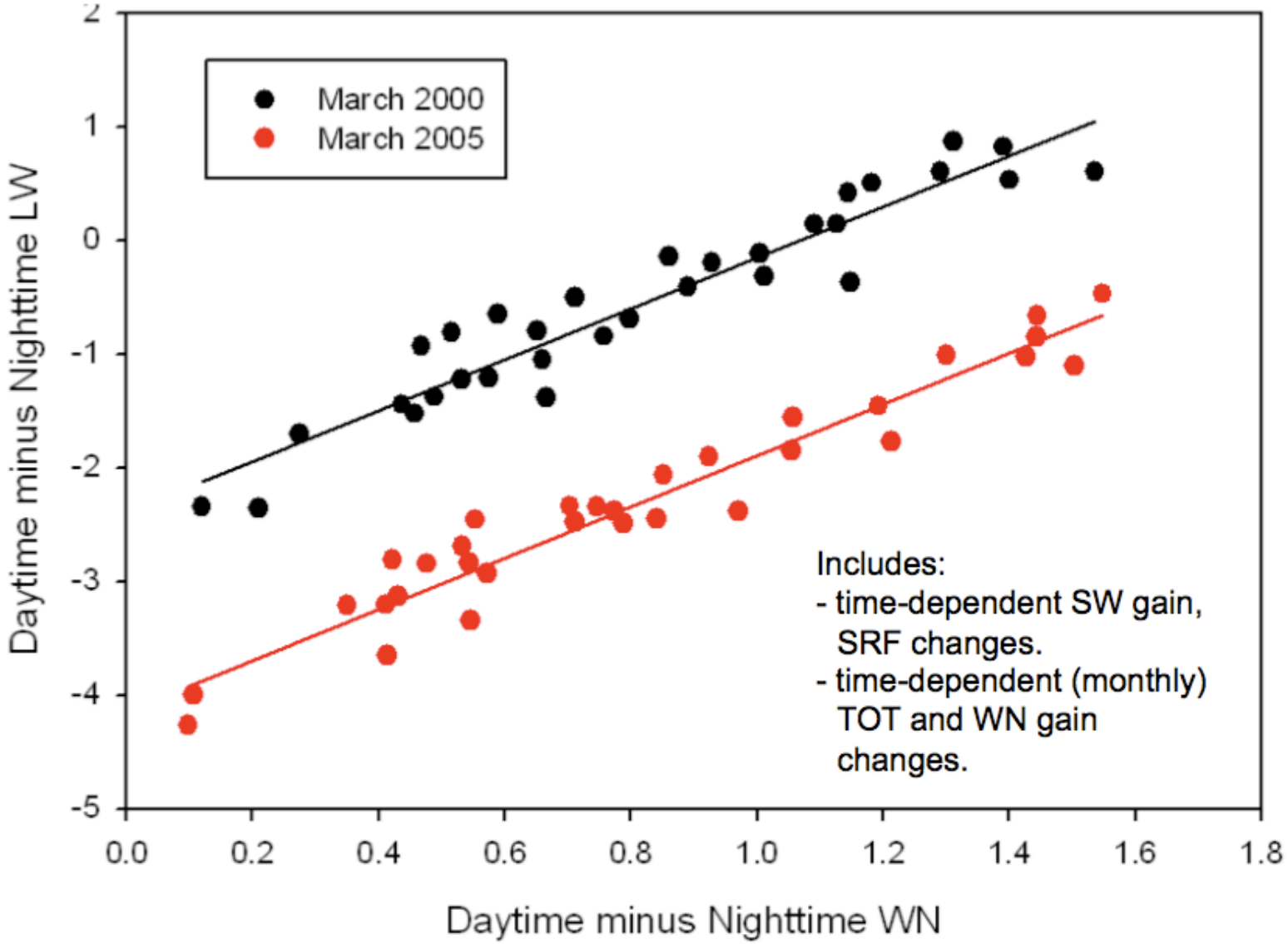
- Decreasing trend in the reflected solar measurements
- Divergence between daytime and nighttime LW fluxes with time


0
-2
-4
-6
-8
% Change from BOM
2000
2001
2002
2003
2004
2005
2006
2007
YEAR
FM1
FM2

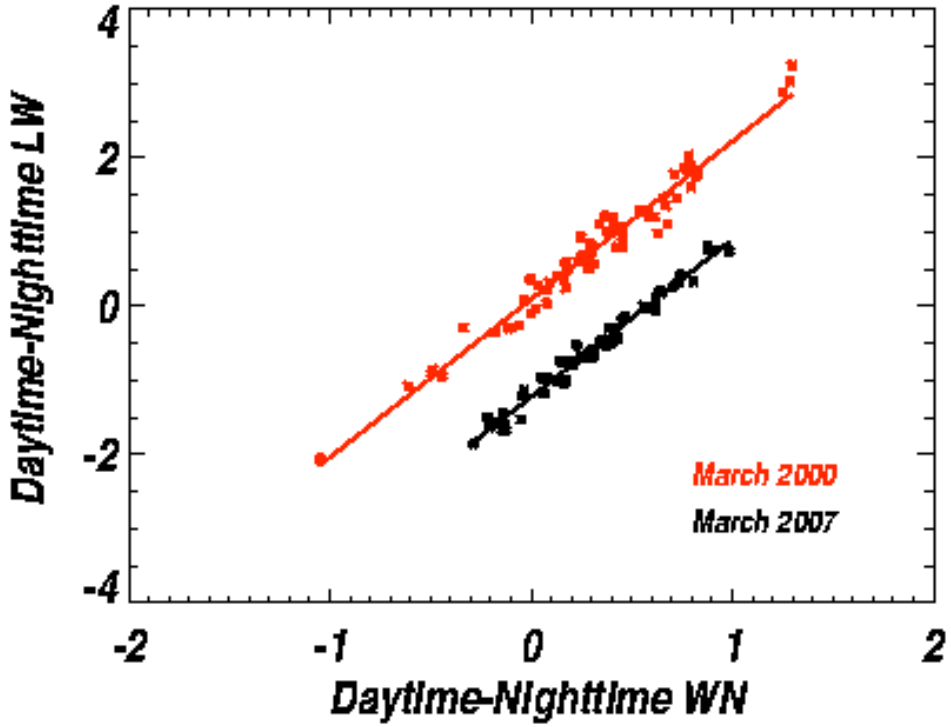

Global Mean Daytime SW
SW TOA Reflected (Wm-2)
-6
-8
-10
-12
-14
Ed3_CERES_Obs - Ed2FuLiou: -8.31 1.62
Ed2_CERES_Obs - Ed2FuLiou: -9.98 1.28
0
10
20
30
40
50
FM1 Month
Global Mean Daytime LW
LW TOA Outgoing (Wm-2)
2
1
0
-1
-2
-3
-4
Ed3_CERES_Obs - Ed2FuLiou: 1.05 0.80
Ed2_CERES_Obs - Ed2FuLiou: -2.08 0.61
0
10
20
30
40
50
FM1 Month
Global Mean Nighttime LW
LW TOA Outgoing (Wm-2)
2.0
1.5
1.0
0.5
0.0
Ed3_CERES_Obs - Ed2FuLiou: 0.87 0.24
Ed2_CERES_Obs - Ed2FuLiou: 1.74 0.25
0
10
20
30
40
50
FM1 Month

Fred Rose

FM1 Zonal Averagse (16S – 16N) for Ocean



FM1 Zonal Averages of Unfiltered Radiances for All-Sky Ocean (30S – 30N) for March 2007



Determining the Optimal Total SRF with ΔL and ΔWn Unfiltered Radiances